## REPORT OF PROF. PARKER'S HUNTERIAN LECTURES "ON THE STRUCTURE AND DEVELOPMENT OF THE VERTEBRATE SKULL"*

### VI.

IN no animal has the study of cranial development yielded richer results than in the frog. In tadpoles, from the time of hatching onwards, such points as the true nature of the trabeculæ, and their distinctness from the investing mass, the fact that the stapes is a segmented portion of the ear-capsule, and not the apex of the hyoid arch, and the relations of the pterygo-palatine arcade have been demonstrated with certainty. Most instructive, also, is the way in which the various arches become segmented, altered in shape, direction, and relative size, and made to subserve the most various functions.

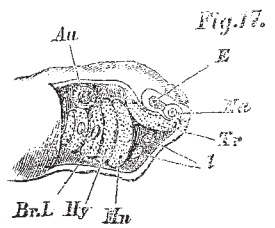


FIG. 17.—Head of Tadpole 2—3 lines long, with the facial arches exposed by removal of the skin from the left side (× 6½).

Besides the adult, nine stages of the frog's skull were described.

1. (Fig. 17).—In tadpoles at about the time of hatching the whole organism is in a very rudimentary condition. The mouth and the gill-slits are closed, the dehiscence of the tissue between the facial arches by which they are formed not having yet taken place. On the first and second branchial arches small papillæ, the rudiments of the external gills, have made their appearance (see Fig. 17). The little creature, now about a quarter of an inch or less in length, is usually found attached to water weeds by the horseshoe-shaped sucker beneath its throat, which, though serving the same purpose, must on no

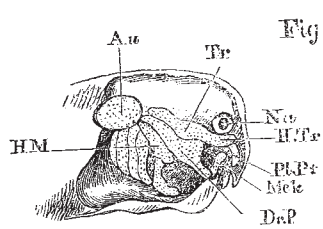


FIG. 18.—Head of Tadpole, 5 lines long (× 6½). Or.P. Orbitar process.

account be confounded with the suctorial mouth of the lamprey. The facial arches are in a perfectly simple and undivided condition, all those behind the mouth are curved slightly backwards in the lower half, while the trabeculæ incline forwards and are thus made to diverge considerably from the mandibulars, although in their upper portion they have almost exactly the same inclination as their successors in the series. The investing mass consists of two small patches of nascent cartilage, one on each side of the notochord. The auditory are the only sense-capsules which have undergone chondrification, and in them the process is quite incomplete, a large membranous space being still left uncovered by cartilage. Two pairs of labial cartilages (l) are formed, and probably answer in a general way to the first and fifth of the series described in the shark (see Fig. 2, $l^1$, $l^5$).

* Continued from p. 168.

2. Tadpole about ⅓ in. long). The external gills have now (four or five days after hatching) become plumose and the mouth and branchial clefts open freely into the pharyngeal cavity. The most important advance is in the commencing separation of a small segment (hypo-mandibular) from the second arch, which in the next stage has become Meckel's cartilage. The hyoid has also begun to diverge from its predecessor in its lower part, and a fourth branchial arch has appeared in addition to the three observable in the first stage.

3. (Tadpole about ½ in. in length, Fig. 18.) The trabeculæ have now united with the investing mass and with each other before and behind the pituitary body, and have become almost horizontal; they likewise begin to foreshadow some of the changes which afterwards take place in them, becoming slender anteriorly, to form the cornua trabeculæ (H.Tr), and just behind the olfactory sac

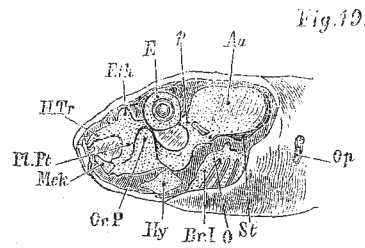


FIG. 19.—Head of Tadpole, 1 in. long (× 4½). Op. Opercular aperture.

being thickened slightly in the future ethmoidal region. Meckel's cartilage now forms a true articulation with the fixed or suspensorial portion of the arch to which it belongs; slightly above the articulation two processes are sent out from the suspensorium; the outer (Or.P) is the *orbitar process*, while the inner (Pl.Pt), uniting with the trabecula, forms a commissural band of cartilage, the rudiment of the pterygo-palatine arcade: between these two processes, the second and third divisions of the trigeminal nerve run. The hyoid arch has assumed a wonderfully shark-like character (see Fig. 2), having divided into an upper and a lower segment, the former of which (hyo-mandibular, H.M) has come into close relation

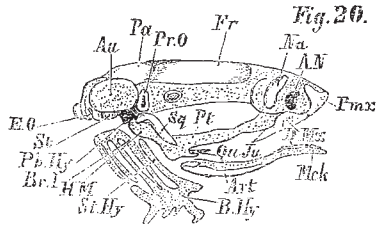


FIG. 20.—Skull of Young Frog, with tail just absorbed (× 5).

with the preceding arch, while the latter hangs free, forming an open angle with the mandible, and unites with its fellow of the opposite side by means of a median basi-hyal. The investing mass and ear-capsules are now completely cartilaginous.

4. (Tadpoles 1 in. long, Fig. 19.) At this stage the hind limbs have made their appearance, and the opercular fold has completely grown over the gill arches on the right side, a small slit (Op) still remaining on the left. The cranial elements have now assumed somewhat the appearance of a skull, which however differs most markedly from that of the adult frog. The trabeculæ, by complete union in their hinder two-thirds with each other and with the investing mass, have formed a solid *basis cranii*; they have also sent up a low wall on either side of the brain, thus tending to inclose it, and just in front of their union with the pterygo-palatine have developed a prominent transverse ridge (Fig. 19, Eth), the rudiment of

the ethmoid. The suspensorium is still greatly inclined forwards, so that the quadrate lies immediately under the ethmoidal region, and, consequently, the palato-pterygoid and Meckel's cartilage, though lengthening, are still extremely short. The hyo-mandibular has completely coalesced with the suspensorium, which is now therefore a compound structure, and presents above two of the three processes mentioned in the axolotl, namely the pedicle (p) and the otic process (o), the latter at this period belonging equally to both arches, the pedicle to the mandibular only. The branchial arches have united with one another above and below to form a perfect branchial basket. The stapes (St) is now completely cut out of the wall of the ear sac, and the first ossification has made its appearance on the base of the skull, in the position of the para-sphenoid.

5. In tadpoles in which the legs have increased greatly in size and the tail has begun to shrink, a marked advance has taken place in the proportion of the jaws to the rest of the skull; the mandibular pier has moved downwards and backwards so as to lie at an angle of 45° with the skull-flow, and the palato-pterygoid and lower jaw are correspondingly lengthened. (Fig. 20 shows the process further advanced.) The orbitar process is greatly decreased in size and lies higher up on the suspensorium, and the ethmoidal cartilage has sent out a vertical keel-like plate (the septum nasi) between the olfactory sacs.

6. The tadpole has now moulted its larval skin, so as to expose the fore-limbs, and the tail is reduced to half its original size. The walls of the brain-case, commenced in the fourth stage, are now complete, and by their union above have formed a roof, interrupted only by their membranous fontanelles, which are persistent in the adult, one in the frontal, and a symmetrical pair of smaller ones in the parietal region. The septum nasi is complete, and two wing-like processes growing from it have inclosed the nasal capsules by uniting with the floor formed by the greatly expanded hypo-trabeculars. The hyoidean portion of the otic process (Fig. 19, o) has now freed itself from its connections, and appears as a triangular nodule of cartilage, the pharyngo-hyal (Fig. 20, Ph.Hy), or detached apex of the arch; at the same time the remainder of the coalesced portion (Figs 18 and 20, H.M) begins to show signs of separating once more from its union with the mandibular pier. Besides the para-sphenoid, the parietal, frontal, nasal, pre-maxillary, maxillary, squamosal, articular, and dentary ossifications have appeared.

7 (Fig. 20). The skull of young frogs in which the tail has just disappeared differs from that described in the last stage, chiefly by the extension of the centres of ossification already mentioned, and the appearance in addition of the exoccipital, prootic, pterygoid, quadrato-jugal, and septo-maxillary. The free portion of the hyoid (St. Hy) has assumed the slender proportions which characterise it in the adult, and it is united by fibre to the upper part of the arch (H.M), which, although still fused with the suspensorium, is marked off from the latter by a distinct depression, and shows unequivocal signs of commencing separation.

8. A most important metamorphosis has taken place in this stage, which includes young frogs just commencing their first summer. The pharyngo-hyal or nodule of cartilage separated from its arch in the sixth stage (see Fig. 20, Ph.Hy) has now come into close contact with the stapes, although it does not actually articulate with it until the succeeding stage; this freed apex of the hyoid arch thus becomes the inter-stapedial piece (Fig. 16, p. 168, i.st) of the ossicula auditus, the representation of the *os orbiculare* of mammals. At the same time the next segment of the same arch (Fig. 20, H.M) has become completely separated from its connection with the suspensorium, and has taken on the form of the other three elements of the chain of ear-bones, the medio-, supra-, and extra-stapedials (Fig. 16, m.st, s.st, e.st), which together are the homologue of the mammalian *incus*. The malleus, although having its functional analogue in the extra-stapedial (the end of the chain fitting into the drum-membrane) is represented morphologically by the frog's suspensorial cartilage, being, as will be shown in a future paper, the proximal end of the mandibular arch.

9. The embryonic characters are now (first autumn) fast disappearing. The suspensorium is at right angles with the long axis of the skull, or almost exact half-way between the positions it occupies in the seventh stage (Fig. 20), and in the adult (Fig. 14, p. 168). The ossicula auditus have come into union with the stapes, and the stylo-hyal instead of being attached (as in Fig. 20) to the suspensorium, has grown backwards to its adult position, where, however, it is united only by fibrous tissue. The parietals and frontals are still separate, and the maxilla has not extended backwards to the quadrato-jugal, although the fibrous space between them is now quite small. The girdle-bone (Fig. 19, G) is singularly behindhand in its ossification; even at this stage it is represented only by a slender plate of bone immediately anterior to the frontals. At a further stage endosteal ossification sets up in the cartilage on either side of this region, so that the girdle-bone is formed by the coalescence of three separate centres.*

## *THE STRICKLAND CURATORSHIP IN THE UNIVERSITY OF CAMBRIDGE*

THE Vice-Chancellor of the University of Cambridge has approved the nomination, by Miss Frances Strickland, of Apperley Court, of Mr. Osbert Salvin, F.R.S., to the office of "Strickland Curator," lately founded and endowed by that lady, and the Museum of that University will therefore reap the benefit of having attached to it one of the best English ornithologists of the day. Mr. Salvin, being then a scholar of Trinity Hall, graduated in mathematical honours in 1857, and immediately afterwards proceeded to join Mr. (now Canon) Tristram in the natural history researches he was making in Algeria, the important results of which are known to many of our readers. In the following autumn he sailed for Central America, and there began that series of scientific observations which has made him the chief authority on the zoology of that part of the world. How many times he has since visited it we cannot say, but he only returned from his last expedition some two months ago, and he has besides been all the while well occupied. In addition to the many papers he has published, mostly on the birds of the Neotropical Region, he has, in conjunction with Mr. Sclater, brought out an illustrated "Exotic Ornithology," intended as a sequel to the celebrated works of Daubenton and Temminck, and in 1870 was chosen editor of the *Ibis*, the leading ornithological periodical of the world.

But our object here is not to sound the praises of Mr. Salvin, who, it will be seen from what we have said, does not requre them, but to point out the advantages that would accrue to science if posts for the study and promotion of its various other branches, similar to the recent foundation, were established in our Universities. We are greatly mistaken if the "Strickland Curatorship" is not the very first step that has been made towards a fulfilment of that idea of the endowment of research which has been often urged in these columns, and was especially recommended in the late Report of the Royal Commissioners on Scientific Instruction and Aid to Science. Admitting that the intention of Miss Strickland was mainly to secure the proper keeping of her late brother's ornithological collection, which was some years ago given by his widow to the University, what will be the effect of the foundation? The merely mechanical part of the curator's

* It should have been stated in the last paper that Fig. 13 is taken from a drawing kindly furnished by Prof. Huxley.